NATIONAL ADVISORY COMMITTEE FOR AERONAUTICS.

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CAUSES OF FAILURE OF AIRSHIP SHEDS.

(Lectures before the "Wissenschaftliche Gesellschaft für Luftfahrt," March 10, 1922.)

I. COLLAPSE OF AIRSHIP SHED A IN NIEDERGORSDORF.

By Dr. R. Sonntag.

II. SUCTION EFFECTS OF WIND ON ROOF OF AIRSHIP SHED "NORD" IN STAAKEN.

By Dr. W. Hoff.

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From "Zeitschrift für Flugtechnik und Motorluftschiffahrt," August 14, 1922.

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I. COLLAPSE OF AIRSHIP SHED A IN NIEDERGÖRSDORF.

By Dr. R. Sonntag.

On March 15, 1921, the daily press reported the collapse, on the preceding day, of airship shed A, which was being taken down at Niediergörsdorf on the site of the former military airship haven of Jüterbog. This shed was built of iron and had the following dimensions: length 184 m; height 28 m clear; width 35 m clear. There were six men killed and several injured three of whom afterwards died from their injuries. The property damage was of little consequence, since the structural parts were sold mostly as junk.

Since hitherto no reliable information has been published concerning the causes of the collapse, it is possible that in foreign countries, and especially in countries hostile to us, false judgments may prevail concerning the strength and safety of German airship sheds. Since such conclusions would be without foundation, it seems proper, before this small gathering of specialists, to delineate briefly the causes of the collapse, so far as this can be done with the information now at our command. The authorities have kindly consented to this, with the understanding that no statements are to be made on the state of the investigation, the names of the individuals or firms inter-

* From "Zeitschrift für Flugtechnik und Motorluftschiffahrt," August 14, 1922, pp. 216-223

ested, or non-technical disputed questions.

The possibility of the collapse of the shed, which was designated for destruction in the treaty of Versailles and which had vindicated its method of construction while in use, naturally followed from the manner of granting the demolition contract. The I.L.U.K. or International Luftschiffahrts-Überwachungs-Kommission (International Supervising Commission of Airship Flight), which was not sufficiently acquainted with German airship shed construction, awarded the contract, with the exclusion of the assistance of competent German officials and without technical specifications, to a general wrecking company, not equal to the task, which, in like unscientific manner, sublet the contract to a wholesale junk dealer who undertook all kinds of wrecking for the sake of the materials. As a former shipowner, he had first undertaken the wrecking of wooden boats, then of camp barracks, etc. This enterprising individual was then attracted by the fine iron of the airship shed, which, as a junk dealer, he wished to sell as soon as possible. Hence the time allowed him for the wrecking was only half as long as that originally allowed by the I.L.U.K.

He chose a wrecking supervisor with as little knowledge of building as himself. He had served as bartender, then as farm laborer and house servant, had once kept a barber shop and is said to have held a position as superintendent of cleaning in a factory. In Niedergörsdorf he was indeed always at his post, but after ten o'clock in the morning he was always in a fagged condition due to excessive consumption of alcohol. The

supervisor and proprietor then entrusted the immediate charge of the demolition of the iron structure to a 23-year-old locksmith, who had once assisted in the demolition of an airship shed as a locksmith under a fitter. There he saw how it was done. Why should he not now in Niedergörsdorf show others how to do it? Especially as he received 50 marks a week more than the other workmen, without being himself even a skilled laborer.

Our German builders had therefore nothing to do with the wrecking of the shed. After entrusting the demolition of such an enormous structure to unskilled men, nothing that might happen could cause further surprise. The collapse was sure to come sooner or later, especially as there was no kind of official supervision, since the contemplated demolition was not announced in accordance to existing police regulations. The only thing remaining to be considered is how the catastrophe actually happened.

The roof covering had been partially removed. The roof supports were three-jointed arches with ridge-pole joint and buttress joints. Fig. 1 shows all the structural parts which had not been removed at the time of the collapse. There had already been removed both end-doors and guides, all supports between purlins 9 and 9, and the longitudinal brace in the side walls as far back as arch 7 and in the rear as far forward as arch 17. Under the roof covering, between arches 2 and 3, the cross-braces between purlins 17 and 17 had been removed and it is highly probable that all of them had been loosened. Of the

longitudinal girders between the upper and lower arches, all the upper members between purlins 13 and 13 had been loosened and the lower members were mostly bent and twisted by the weight of the upper members which, with their braces, were tilted and hanging sidewise. Lastly, the ridge-pole and the footway under it had been removed to about the middle of the shed, so that the ridge joint was no longer braced laterally. The buttress joints still held, because the walls below them were lined with masonry and the stays had not been removed.

The wrecking was so planned that first the footway and purlins were removed in as perfect condition as possible for sale as structural iron, then the arches, down to the buttresses, were to be pulled over one at a time and cut up autogenously and sold for scrap. No stationary nor movable scaffolding was employed in the wrecking. After the individual arches were detached, they were to be held by ropes on both sides until they were pulled down. The door frames and guides had already been taken down in this manner.

In the condition shown in Fig. 1, all the arches had been detached to such an extent that their security was endangered. Relatively small eccentricities of the columns or spans or of the lateral forces could have easily caused them to break down. A strong gust of wind would have perhaps sufficed. The most endangered points, namely the top ends of arches 1 to 3, were subjected to considerable additional stresses, since heaver-arms were attached to the side of arch 2 for lowering the pur-

lins. These arms must have exerted bending stresses on the arches, the effects of which would increase, as more purlins were removed. One of the men, who was working on a heaver-arm after most of the purlins had been removed, escaped with his life, though not without severe injuries. He remembered that the top of arch 2, just before the collapse bent toward the end of the shed. This arch, in falling, brought down the others with it.

Abnormal changes must have taken place previously, since a workman engaged in removing the wall braces had heard a crackling of the whole structure. This was doubtless caused by the fact that, in the shed, which was nearly ready to collapse, the stress of the bending portions of the arches had already reached the elasticity limit, so that the sheet-iron covering came loose, thereby establishing a condition which is plainly recognizable externally on an unpainted iron covering by the appearance of the so-called Hartmann lines or strain figures and is known as the strain condition of the iron. The actual collapse followed suddenly, after the stress in many of the parts had reached a point endangering the strength and stability of the whole structure.

The masonry of the side walls remained intact up to the height of the buttress joints. The half-arches evidently bent at the top, since the wall portions of the arches fell perpendicularly to the wall and in front of their pivots or buttress joints. The bending of the foremost portions of the

arches proceeded from the fact that in arch 1 the bending top shot sidewise in advance, so that the tops of the half-arches shut together, resulting in a distortion of the whole arch.

The feet of the arches fell at right angles to the wall toward the middle of the shed, after the bending had occurred at the top of the arches. In the wrecking, a door frame fell sidewise toward the middle of the shed and somewhat toward the rear. There was also a further possible cause for collapse, in the slipping backward of the foot of an arch against the foot of the next arch and thus causing the latter and even other arches to fall prematurely. This was the more liable to occur, because those in charge of the wrecking had taken no precautionary measures.

The shed would probably not have collapsed if the wrecking had been done by a regular German construction company, preferably by the same one that built the shed, or even if it had at least been announced to the building authorities, so that it could have been officially supervised. One or the other course would certainly have been followed if the wrecking had been entrusted to German building authorities, instead of to foreign laymen.

A large shed was taken down at the same time, but with a regular movable scaffold. The wrecking was done by an iron construction company and progressed without accident. This shed was delivered in Japan and there set up again, but has since been wrecked by an airship explosion. There is, there-

fore no cause for alarm on the part of those using German airship sheds, either at home or abroad, concerning the safety of such sheds.

For the purpose of preventing similar disasters, in which human lives are always endangered, it is to be hoped that the guilty parties will be punished, so that not only they themselves but all others will have no desire to undertake tasks which can be properly performed only by skilled engineers.

2. SUCTION EFFECTS OF WIND ON ROOF OF AIRSHIP SHED "NORD" IN STAAKEN.

By Dr. W. Hoff.

We have all followed the convincing arguments of Dr. Sonntag with interest. Since the reason for the collapse was unknown to me before the lecture, I had assumed that it was due to aerodynamic defects. The lecturer has shown that no such defects entered into the question and that the collapse was due only to criminal carelessness.

At noon on December 18, 1921, a northwest wind-storm inflicted great damage on Berlin and its suburbs. It tore off portions of the roof coverings of the sheds of the Zeppelin Airship Company and of the German "Luft-Reederei" in Staaken. It also damaged several of the buildings of the German Experimental Institute for Aviation at Adlershof.

The damages to the airship shed in Staaken are worth considering. Of the former two airship sheds, 252 meters long,

46 broad and 38.4 high, with an intervening shed 16 meters high, there still remained the latter and the north airship shed. This was covered partly with glass and partly with plates or slabs of pumice concrete (see Figs. 3 and 4).

The storm struck the airship shed at an angle of somewhat less than 45 degrees, tore off a row of concrete plates about 70.8 meters long half-way up the roof, blew them over the ridge-pole and deposited them on the shed in the lee of the airship shed. The distance the plates were carried varied between 45 and 60 meters.

Each plate measured 2.36 x 0.6 meters, thus having a surface area of 1.416 square meters. With a unit weight of 80 kg, this gives a weight of about 57 kg per square meter. The total weight of the plates torn off is about 10,000 kg.

The destruction took but a short time, so that the few witnesses were reminded of war events. Fortunately, on account of its being Advent Sunday, there was no one in the shed, so that only property damage resulted.

The explanation of the damage caused by the storm is to be sought in the aerodynamic action of the wind on the buildings. In 1914, G. Eiffel published an account of experiments with models of airship sheds,* which he had performed in his wind tunnel. The case in question is that of a closed shed with no opening in the top for equalizing the air pressure within and

* G. Eiffel, "Nouvelles recherches sur la resistance de l'air et l'aviation, Paris, H. Dunod et F. Pinat, 1914.

without. The Staaken shed, in fact, had air-pressure, equalizing valves, but their effect was insufficient. Plate XXIX of Eiffel's Atlas (Fig. 2) gives wind-pressure distribution diagrams, which may be used here for comparison.

Fig. 2 shows the distribution of the pressure on the middle section and on the front gable wall of a shed model, created by an air stream with a velocity of 40 m/sec striking it at an angle of 60°. Toward the gable wall, on the windward side of the roof, the negative pressure decreases somewhat, though the manner of distribution is not changed.

It is seen that the location of the plates blown off is at the point of greatest suction and that their weight per square meter corresponds to the negative pressure in the Eiffel diagram. We may therefore conclude that the wind had a velocity of about 40 m/sec at the time of the disaster.

Translated by the National Advisory Committee for Aeronautics.

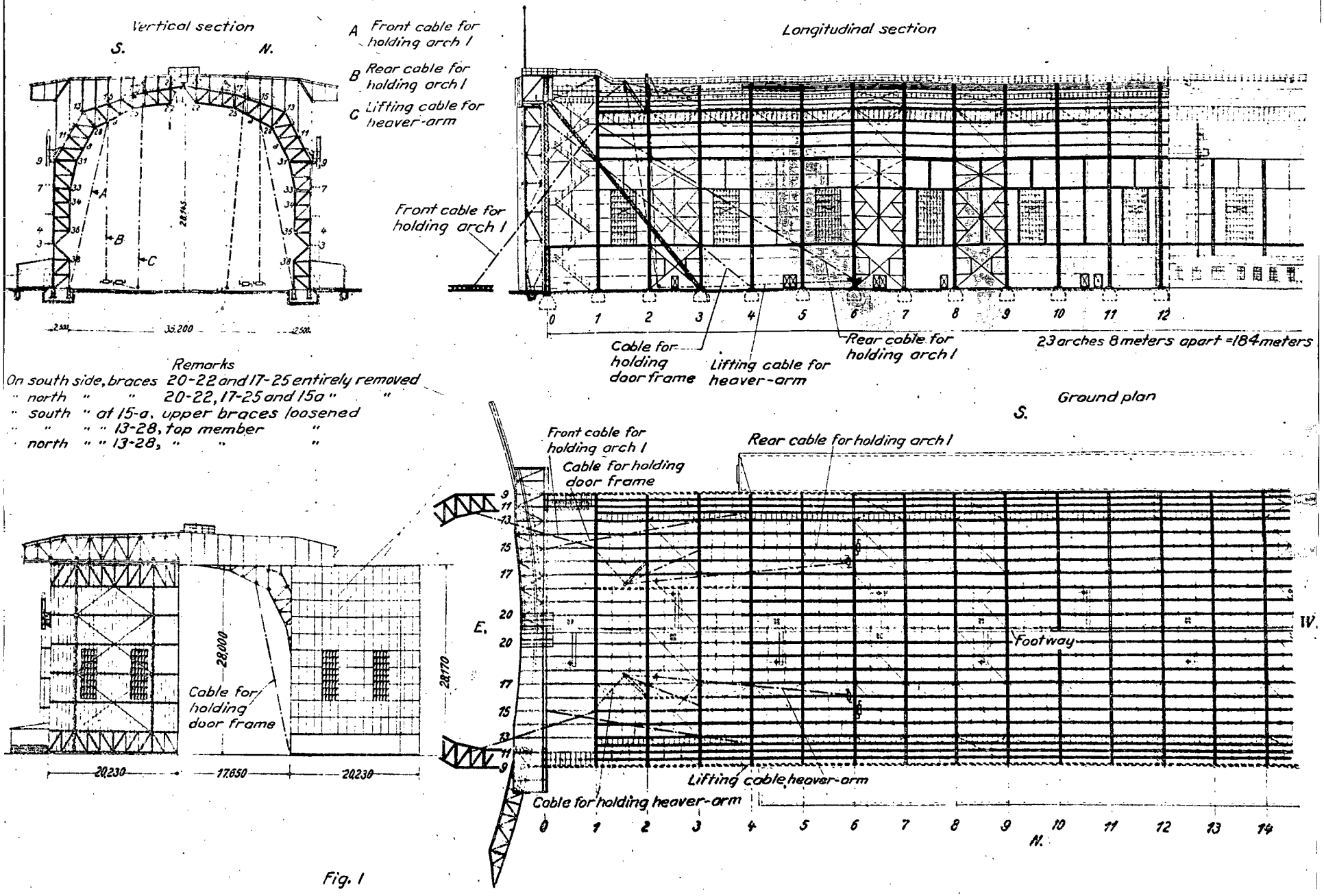
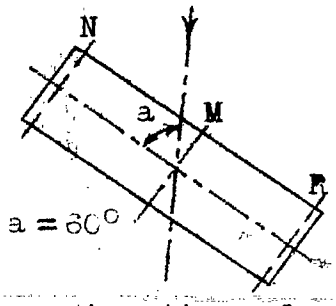
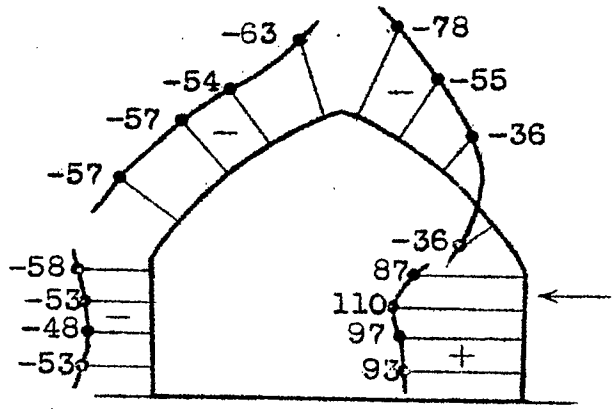

Vertical section
S.
N.
A Front cable for holding arch I
B Rear cable for holding arch I
C Lifting cable for heaver-arm
28.745
35.200
2.550
2.550
Longitudinal section
Front cable for holding arch I
0 1 2 3 4 5 6 7 8 9 10 11 12
Cable for holding door frame
Lifting cable for heaver-arm
Rear cable for holding arch I
23 arches 8 meters apart = 184 meters
Remarks
On south side, braces 20-22 and 17-25 entirely removed
" north " " 20-22, 17-25 and 15a " "
" south " at 15-a, upper braces loosened
" " " " 13-28, top member "
" north " " 13-28, " " "
Ground plan
S.
Front cable for holding arch I
Cable for holding door frame
Rear cable for holding arch I
Footway
Lifting cable heaver-arm
Cable for holding heaver-arm
0 1 2 3 4 5 6 7 8 9 10 11 12 13 14
N.
E.
IV.
28,000
28170
Cable for holding door frame
20.230
17.650
20.230

Fig. I

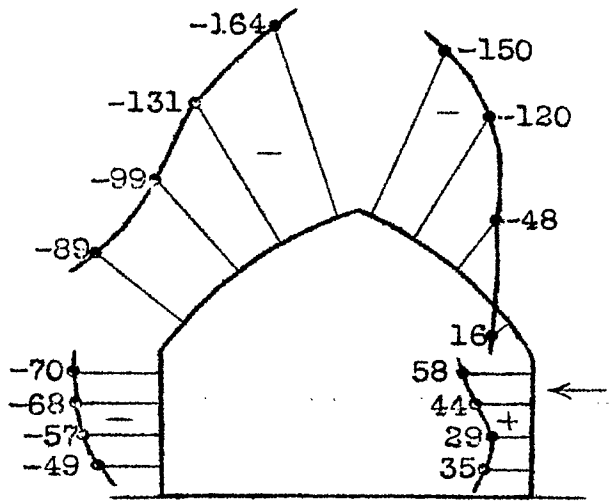


Angular direction of wind 60°



Front gable wall

Note:- Wind pressures are given in kg/m^2 for a wind velocity of 40 m/sec



Middle section

Fig.2 Air pressure distribution on model of airship shed, according to Eiffel. Plate XXI of Atlas

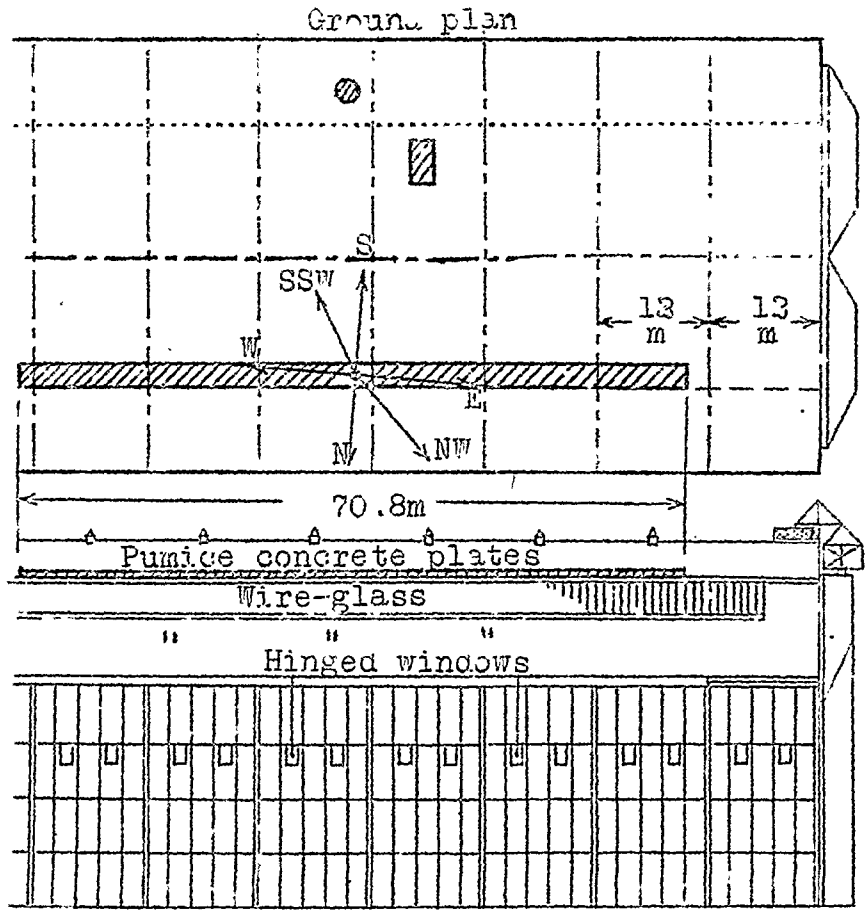


Fig. 3 Ground plan and longitudinal elevation of damaged portion of airship shed "Nord" in Staaken. The cross hatching indicates damaged portions of shed roof.

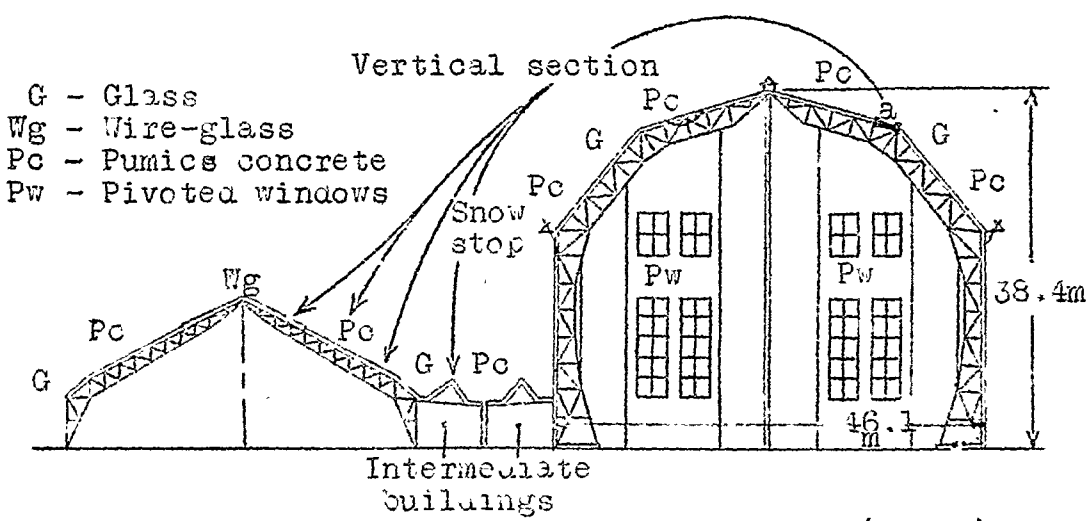


Fig. 4 Storm damage to airship shed "Nord" (right) in Staaken Dec.18,1931. Middle shed on left. At "a" the concrete plates were torn off by the storm.